University of Heidelberg

Department of Economics

Discussion Paper Series | No. 633

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June 2017

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Abstract

In the wake of several high-profile natural disasters, crowding effects between public relief and private investments in disaster preparedness have recently attracted renewed attention. We examine how non-hypothetical self-insurance behavior by households responds to variations in public investments in relief capabilities based on a large disaster preparedness survey (n = 19,071) conducted in Japan in 2012. The preparedness measure used is emergency drinking water storage, defining a setting in which (i) government provides in-kind, rather than cash, relief and (ii) the crowding effect observed is more apt to be total, rather than partial. In contrast to much of the literature studying crowding effects of cash relief, there is little evidence for crowding out in emergency drinking water, with an upper bound of 2 percent at the intensive margin.

Keywords: Crowding-out; disaster preparedness; government relief, natural hazards, in-kind relief.

JEL classification: D78, D81, G22, Q54

Acknowledgements: Valuable comments on previous drafts of this paper have been provided by Christian Almer., Richard Butler, Luisa Dressler, Malte Lech, Paul Raschky, and Paul Schaudt as well as conference and seminar audiences at the 2016 EAERE conference, the Workshop on the Geospatial Analysis of Disasters and the CEAR/MRIC Behavorial Insurance Workshop 2016. We are grateful to Hiroki Onuma and Shinya Horie for research assistance. T. Goeschl's research has been supported by a travel grant from the HeKKSaGOn network. S. Managi's research has been supported by a Grant-in-Aid for Specially Promoted Research (26000001) by the Japanese Society for the Promotion of Science.

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1. Introduction

Modern societies remain vulnerable to disasters such as earthquakes, hurricanes, and tsunamis. Such low-probability high-impact events are associated with substantial losses in human welfare. The magnitude of human welfare losses can be mitigated significantly by investments into emergency preparedness, however (Kahn 2005). In fact, even moderate levels of preparedness in the form of emergency supplies can have substantial impacts on morbidity and mortality during catastrophic events (Conolly et al. 2004; Tanaka et al. 1999). As a result, many countries attempt to attain high levels of domestic preparedness by combining initiatives to encourage individual preparedness at the household level with a variety of governmental and non-governmental efforts to provide emergency relief when natural disasters occur.

The present paper contributes to a growing empirical literature that analyzes the relationship between public and individual disaster preparedness, much of it motivated by the common observation that the average household is insufficiently prepared (e.g. DIEM 2010). Understanding more about this relationship is important for both researchers and policy-makers: If publicly-provided emergency relief negatively affects households' choice of preparedness, this would provide additional empirical support for the 'crowding-out' effect of public interventions postulated in the seminal paper by Ehrlich and Becker (1972). If present, crowding-out can have significant impact on the effectiveness of public preparedness efforts since public investments have no or only fractional impact on the overall level of preparedness.

The presence and scale of a crowding out effect has been the subject of several empirical studies that draw on evidence from a variety of natural disasters. Various studies find evidence in line with crowding-out (e.g. Kunreuther 2006, Botzen et al. 2009, Kousky 2013, Brunette et al. 2013) and highlight the possible causal channels through which crowding out can operate. One channel is the simple mechanism of risk compensation (Ehrlich and Becker 1972): Fully informed and perfectly rational households may want to avoid excessive preparedness in a setting where public measures reduce expected damages from a catastrophic event (Botzen et al. 2009). Such risk compensation can be, but need not be welfare-reducing. If preparedness can be provided more cheaply by government, then private investments should be reduced in response to public investments under social efficiency considerations.

Less ambiguous in welfare terms is the channel of 'charity hazard' (Browne and Hoyt 2000): This concept, closely related to moral hazard, refers to the *strategic* reduction of damage-limiting prevention by households when governments already offer an efficient level of preparedness. Charity hazard captures the decision by private households to reduce preparedness below the efficient level because they know that government cannot credibly commit to *not* providing additional damage-relief in the event of a catastrophe. Such strategic behavior is welfare-distorting and means, as Buchanan (1975) pointed out, that governments face a 'Samaritan's dilemma' in emergency relief (Raschky and Schwindt 2016).

A third channel is perception bias: Private households may overestimate the effectiveness of public interventions in providing disaster relief and, as a consequence, lead households to underestimate the damages from potential disasters and to under-invest in market-based insurance and self-protection (Kunreuther, 1996). The three channels do not appear to be always operative at detectable magnitudes, however: Despite similar settings, other studies fail to identify crowding out in their data (Kousky et al.

2013, Koerth et al. 2013) or find that there is considerable heterogeneity across subjects (Osberghaus 2015). This points to important subtleties in the mechanisms and diagnostics of crowding out.

Against the existing evidence on crowding out, the present paper examines a particular disaster preparedness setting, namely private and public investments in emergency drinking water (EDW) supply in Japan for the year 2012. The amount of EDW stored publicly and privately is a valuable measure for disaster preparedness since its availability has a dramatic impact on mortality and morbidity rates following a catastrophic event (Watson et al. 2007).[1] This choice of a setting enables the paper to make at least two contributions. The first is that it provides an opportunity to examine in-kind relief, as opposed to cash relief, as the publicly provided insurance good. In many circumstances, governments provide in-kind relief, such as emergency shelter, food, and drinking water, for populations afflicted by natural catastrophes. Almost all the evidence on crowding-out, however, comes from settings in which government offers cash relief (Raschky and Schwindt 2016). The form of relief may not be inconsequential in terms of crowding effects, in particular when markets are incomplete,[2].but also for behavioral reasons. The extent to which results from cash relief carry over to in-kind relief is an open question. The second contribution of the paper is that its results on crowding are largely immune to a key challenge raised by Ehrlich and Becker in their seminal 1972 paper: In equilibrium, they argue, there should be no arbitrage left between publicly provided risk reduction on the one hand and across the three options of market insurance, self-insurance,

[1] In developed countries, the contribution of EDW to morbidity and mortality reduction mainly relates to water *safety* rather than water availability. In a post-disaster environment, disruption of access to uncontaminated drinking water ranks as a primary concern since populations quickly become vulnerable to water-borne diseases.

[2] When capital markets are incomplete and households are liquidity constrained, cash relief could arguable induce crowding effects simply by allowing households to monetize illiquid assets.

and self-protection on the other. Ideally, therefore, the researcher would be able to observe choices across *all three* options in order to evaluate the efficiency and welfare effects of these choices before and after the exogenous change in publicly provided risk reduction. In practice, however, the researcher will typically observe only a subset of these choices, for example the change in households' demand for market insurance (e.g. Raschky et al. 2013, Kousky et al. 2013). While such data can inform statements on the *partial* impact of increased public intervention on market insurance, a *total* assessment of whether crowding out has occurred requires a comprehensive picture of the household's response to increased public intervention also across self-insurance and self-protection. The finding by Osberghaus (2015) that the overall vulnerability of households to flooding events is the result of a complex interplay between public flood protection, the private demand for flooding insurance, and private flood mitigation measures is a case in point. The present setting allows the total effect to be estimated with considerable confidence because two out of the three alternative options mentioned by Ehrlich and Becker are not available in the case of EDW: Investment in EDW has no close substitutes and can privately only be provided on a cost-effective basis through self-insurance[3] and not through market insurance or self-protection.[4] In a setting with such a restriction of options, the response of private EDW storage to an increase in public EDW supply can therefore confidently be expected to provide a close approximation to the total impact. Also, since public and private EDWS provide a perfect substitute, namely drinking water, the setting allows crowding effects to be assessed on a liter-for-liter basis, making the effects stark.

[3] Conceptually, self-insurance is the most appropriate definition for behavior in which households store EDW in their own home.
[4] Self-protection could – theoretically – take the shape of activities such as sinking private wells or purchasing water filtration equipment. Such measures are typically either not available (wells) or not cost-effective (water filtration).

To test for the presence and scale of crowding out of private emergency preparedness by public preparedness measures, we use unique household survey data from 19,071 households in Japan in 2012. The location, timing, and focus of the survey are significant: Japan is a country with areas that are exposed to a high risk of natural disasters and a recent history thereof. The population is deeply aware of the presence of natural hazards and public measures intended to manage the resultant vulnerabilities. Japan is also a country in which the private cost of specific preparedness by ensuring adequate EDW storage is high. Internationally exceptional residential dwelling density (Keirstead and Shah 2012) and resultant housing costs (Kanemoto 1997) lead to a high opportunity cost of sacrificing residential space for emergency water storage, which amounts to around 24 liters for a typical family of four.

The timing of the survey is also significant: In 2012, the central coastal regions of Japan's main island constituted a typical post-disaster environment in the wake of the 2011 Tohoku Earthquake, the subsequent tsunami event, and the nuclear accident at Fukushima Daiichi. As a result, the topic of the survey had cognitive salience and the survey population was generally well informed about disaster relief, public preparedness etc. The key source of variation in our dataset comes from the different levels of local public preparedness in the form of investments into public EDW storage. While there are national recommendations on how much EDW a community should store, communities vary considerably in their preparedness. Across Japan's 47 prefectures, public EDW ranges from 01*l* per person to more than 65*l*.

A natural concern is the direction of causality that links public and private preparedness in EDW storage. *Prima facie*, variations in public preparedness could conceivably be driven by officials being informed about private preparedness and adjusting preparedness appropriately, rather than the other way around. While this possibility can no longer be excluded after 2014, when the first systematic assessment of private preparedness at the local level was conducted, at the time of our own survey such information is not considered to have been generally available. This makes reverse causality less likely for Japan in 2012.

Against this empirical background, we examine the presence of a negative statistical relationship between public and private EDW storage through multivariate regression analysis, using control variables to account for well-known determinants of self-insurance such as risk exposure, disaster experience, and other socio-demographic characteristics. The headline results confirm the presence of statistically significant, but unsubstantial crowding-out effects of governmental intervention on private households' disaster preparedness. At the extensive margin, there is not effect of additional EDW storage by government on the propensity that the average household will decide not to store any EDW. At the intensive margin, we find that among those households that store a positive amount of EDW, but less than the officially recommended amount, every additional liter per capita (*lpc*) of public EDW supply reduces private EDW storage by around 0.02*lpc*. The effect is highly robust to the inclusion of controls, estimation methods, and thresholds. It implies a crowding-out of approximately 2 percent. An examination of the covariates shows that the extensive and intensive margin decisions broadly respond to the same factors. But there are also some important differences. For example, households' EDW provision is highly insensitive to the number of dependent members (children and elderlies in need of medical support). In other words, the private storage of EDW of households with and without dependent members is essentially the same. This points to the potential gains from EDW relief targeted at households with dependents.

In the following Section 2, we provide an overview of the existing literature. In Sections 3 and 4, we describe our data and estimation method. In Section 5, we present and interpret our estimation results, and in Section 6, we provide concluding remarks.

2. Related Literature

The theoretical study of a crowding out effect of public insurance on self-insurance goes back to at least the early seventies when Isaac Ehrlich and Gary Becker published their seminal study on the interaction between market insurance and self-insurance (Ehrlich and Becker 1972). Their insights were subsequently applied to the study of natural disaster preparedness (e.g. Lewis and Nickerson 1989, Quiggin 1992, Crocker and Shogren 1999, Zehaie 2005; Mahmud and Hassan 2014), lending theoretical support to the notion that there is an inverse relationship between public relief efforts and private preparedness for natural disaster risks.

The empirical literature on the topic has adopted a variety of research strategies in order to test for the presence, direction, and strength of crowding effects of government-provided disaster relief. A number of studies conduct surveys that elicit hypothetical willingness to pay for insurance against the backdrop of expectations about government assistance. Asseldonk et al. (2002) examine demand for crop insurance among Dutch farmers and find evidence for crowding out. So do Botzen et al. (2009) in a survey of Dutch homeowners that examines their willingness to provide self-protection through domestic mitigation measures. Botzen and van den Bergh (2012a,b) support this finding with similar results on flood insurance demand in a large sample of around 1000 Dutch homeowners. Raschky et al. (2013) survey around 500 households in Germany and Austria in a post-disaster period to elicit WTP for flood insurance and also find evidence for crowding out by governmental disaster relief, with additional nuances on account of differences in the certainty and volume of relief between the two countries. The consistent empirical evidence that hypothetical WTP for insurance negatively varies with expected government relief is also supported by related evidence derived under controlled conditions: Brunette et al. (2013) conduct a framed laboratory experiment with forest owners in which different treatments vary the nature and amount of "public support" in the case of an adverse forest event. They find that such relief reduces the demand for insurance, irrespective of whether the uncertainty is of a classic risk type or involves ambiguity. Turner et al. (2014) conduct experiments in post-disaster Pakistan with subjects affected and not affected by the flood event and find that having received government assistance for major disaster recovery reduces demand for insurance in the experiment.

Despite the clear evidence for crowding out from surveys that elicit hypothetical WTP and from a laboratory study, empirical studies that rely on actual insurance data do not always arrive at the same conclusion. Browne and Hoyt (2000) examine the frequency of flood-insured households in different US states and find evidence for crowding in of federal disaster assistance on private flood insurance at the state-level. Petrolia et al. (2013) confirm this finding based on individual-level survey data from the US Gulf Coast and Florida's Atlantic Coast: The propensity of holding a flood policy increases with perceived eligibility for federal disaster assistance. Kousky et al. (2013) question the validity of these findings on the grounds of endogeneity problems. They propose an identification strategy based on that fact that federal disaster assistance has a politically discretionary component. Using political contestability ('swing state') as an instrument and individual flood contract data, Kousky et al. find a crowding out effect at the order to \$6 for every \$1 increase in federal aid grants, but no effect for government loans. Osberghaus (2015) examines German household survey data on individual flood event mitigation efforts in the wake of large-scale floods in 2013. This study does not find evidence for the hypothesis that expected relief payments by government crowd out private investments in preparedness.[5]

In light of the results in the literature, the empirical support of crowding out effect therefore is not clear-cut once we step beyond the domain of hypothetical WTP measures. The present study presents such a step: It adds to the current evidence base by bringing new insights from a large-scale survey about self-insurance to bear on the question of crowding. In this, the study relies on self-reported actual behavior rather than on hypothetical behavior and therefore adds evidence to the literature in that area where the presence of crowding out is most in question.

Without exception, investigations into the presence of a crowding out effect control for the presence of additional drivers of households' disaster preparedness for which the researcher needs to control. There is general agreement on risk exposure, disaster experience, risk management posture as well as socio-demographic characteristics as key variables of interest. These drivers have been identified and

[5] Raschky *et al.* (2008) and Neumayer *et al.* (2013) show that crowding effects can also operate at the international level (see also Cohen and Werker, 2008).

assessed both the papers interested in crowding effects (see above) as well as papers that choose not investigate this causal link (e.g. Donahue et al. 2013 or Koerth et al. 2013).

Table 1: Empirical findings on significance and direction of drivers of preparedness

Driver of preparedness	Estimated direction	Study
Public preparedness	Positive	Brown and Hoyte (2000); Petrolia et al. (2013).
	Insignificant	Osberghaus (2015).
	Negative	Asseldonk et al. (2002); Botzen et al (2009); Botzen and van den Bergh (2012a,b); Raschky et al. (2013); Kousky et. al (2013); Turner (2014)
Risk exposure	Positive	Donahue et al. (2013) ; Osberghaus (2015); Botzen et al (2009); Raschky et al. 2013; Asseldonk et al. (2002)[6]
	Insignificant	Asseldonk et al. (2002)[7]
	Negative	Koerth et al. (2013)
Disaster experience	Positive	Donahue et al. (2013) ; Koerth et al (2010) ; Brown and Hoyt (2000); Osberghaus (2015) ; Turner et al. (2014) ; Asseldonk et al. (2002)[8]; Raschky et al. (2013)[9]
	Insignificant	Botzen et al. (2009) ; Asseldonk et al. (2002)[10]; Raschky et al. (2013)[11]
Risk management posture (implicit risk premium)	Positive	Osberghaus (2015);Donahue et al. (2013); Petrolia et al. (2013)
	Insignificant	Raschky et al (2013) ; Asseldonk et al (2002)
Income	Positive	Osberghaus (2015); Raschky et al. (2013); Browne and Hoyt (2000)
	Insignificant	Botzen et al. (2009); Turner et al. (2014)
Education	Positive	Botzen et al. (2009); Donahue et al. (2013)
	Insignificant	Osberghaus (2015); Asseldonk et al. (2002)
Children present	Insignificant	Osberghaus (2015); Petrolia et al. (2013)

As table 1 illustrates, there is considerable, but not universal agreement on the importance of these

6 The positive result applies to the extensive margin estimation in a double-hurdle model.
7 The insignificant finding applies to the intensive margin estimation in a double-hurdle model.
8 Result for the extensive margin in a double-hurdle model.
9 Result for the effect of damage size.
10 Result for the intensive margin in a double-hurdle model.
11 Result for the frequency of damage.

drivers and their direction of impact. The same drivers play a role despite inevitable differences in the empirical implementation of the underlying concepts given the available data for each empirical study and the different methodological strategies. Apart from public preparedness, for almost all of the identified drivers, there is consistent evidence of a nonnegative relationship between the level of the variable and the estimated direction of how it impacts on preparedness. This convergence in estimated effects provides a set of predictions on what patterns to expect in any new dataset, such as the one underlying the present paper.

3. Empirical strategy, data, and descriptive results

The empirical strategy adopted in this paper focuses on EDW for three reasons: First, immediate access to EDW is essential in a post-disaster environment since the consumption of contaminated drinking water is a leading cause of post-disaster morbidity and mortality. Second, EDW is a generic good, with government relief a very close to a perfect substitute for private provision. Third, private EWD provision is costly due to the high opportunity cost of storage space in Japan. Exploiting this particular setting, we assess the impact of local governments' preparedness with respect to EDWS on household-level preparedness. The particular setting also contains important corroborating institutional details that allows us to argue that the direction of causality is not in question. Local governments in Japan, like governments elsewhere, are subject to long planning horizons and a high degree of institutional and procedural inertia (Donahue 2011). This limits the responsiveness of local government to intertemporal variations in disaster preparedness by private households. The most important piece of evidence is, however, the fact that the first study to inform local governments about citizen preparedness following the 2011 Tohoku disaster was only conducted in 2014 (Nakayachi et.al 2015). Even before that, local governments' supply side orientation in disaster relief has meant that households' risk perception or patterns of preparedness were rarely investigated in Japan. This is, in fact, not unusual: Also in countries such as the US, officials are typically vaguely aware of the true level of disaster preparedness in the population, and regional or local variations within these levels (Donahue 2011).[12] Japanese households, on the other hand, have traditionally received information about how their local governments reinforce disaster preparedness, a trend that has increased through the use of social media in recent years (GoJ 2012). Most prefectures distribute information leaflets on disaster preparedness to households and information on EDW provision by prefectures is explicitly available through the Internet.[13] This leads to a situation in which households are much better able to condition their individual levels of preparedness on what they know about the government's efforts rather than the other way around.

Household data on disaster preparedness comes from a large-scale survey, the 2012 Survey of Individual-Level Preparedness for Natural Disaster. The purpose of the survey was to generate a comprehensive picture of disaster preparedness among Japanese households. For the purposes of this study, disaster preparedness of each household is measured by reference to the amount of EDW that the household should – given its size - store according to official guidelines and the amount of EDW that the household actually stores. Households are expected to store independently enough water to survive the first 72 hours after a disaster. The officially recommended EDW amount is 6 liters of water per

[12] Donahue et al (2013) also find that there are fundamental differences between officials' perceptions of citizens' preparedness and citizens' perception of own preparedness.
[13] One English-language example is provided here: http://www.city.hyuga.miyazaki.jp/display.php?cont=160418152455 (accessed on March 10, 2017)

household member, with appropriate reductions for younger HH members.[14] This allows a first rough categorization of households according to preparedness status. We will refer to a household as *unprepared* if the amount of EDW it stores is zero. A household will be categorized as *underprepared* if there is a positive amount of EDW stored, but less than recommended by official guidelines. Finally, *prepared* households store an amount of EDW that fulfils or exceeds official guidelines and therefore have no shortfall.

In addition to information on preparedness, the survey also collected data that relate to those determinants of disaster preparedness that the literature has established as important drivers (see section 2). These are variables that measure risk experience and risk attitudes, in addition to a number of socioeconomic variables. On risk experience, households are asked on a yes/no basis whether they have personally been affected by a disaster in the past (*EX-disaster*), whether they have personal experience of seeking refuge in an emergency shelter (*EX-shelter*), whether they were personally affected by the 1995 Kobe earthquake (*EX-Kobe*). For experience of the 2011 Tohoku earthquake (*EX-Tohoku*), we compare the residence location of a household at the time of the earthquake with its impact zone and code for experience if the residence was located there. On risk attitude, the survey collected yes/no responses on whether the household head had participated in a disaster drill in the last five years (*training*) or considered himself generally compliant with official guidelines and health recommendations (*compliance*). Socio-demographic variables include the population density of the prefecture in which the household is

[14] For a HH member of 13 years of age or older, the amount is 6 liters. For the age group between 8 and 12 years, the supply is set at 4.5 liters and at 3 liters for ages below 8 years. Given the age composition of a HH, there is a specific recommended level of EDWS (in liters) composed of the sum of individual EDW needs. So a family with two adults, child aged 10 and another aged 6 would have to maintain a total supply of 19.5*l* EDW in storage continuously in order to comply with the recommendations.

located (*density*) as well as household income (*income*), household size, years of secondary education (*education*), number of children under 5 years of age (*children*), and the number of elderlies above 64 years of age that require medical care (*elderlies*).

Data on public preparedness and on households' risk exposure comes from local governments' natural disaster aid data available from the Fire and Disaster Management Agency (FDMA), which is a part of the Japan Ministry of Internal Affairs and Communication (MIC). FDMA provides disaggregated annual data on the provision of drinking water and other emergence commodities. With the survey conducted in 2012, we use data from 2011 on the basis that citizens' decision making is based on the information about the previous year. FDMA also provides data on the number of FDMA officers allocated by the national government to each community and on the city-level budget expenditures for the mitigation and recovery from disaster. We choose to proxy *risk exposure* of a household through two variables: One variable captures past exposure through the cumulative expenditures on disaster recovery per square kilometer by the relevant prefecture since YEAR (*expenditure*). The other variable measures officially expected future exposure measured through the number of professional emergency workers per one thousand inhabitants allocated by the national government to the community in which the household is located (*professionals*).

The survey sample consisted of 19,071 households from across Japan. The sampling frame was designed to randomly select respondents while preserving the population composition of Japan's population between the ages 20 to 69 in key socio-demographic dimensions. We designed and outsourced the survey to a marketing company (Nikkei Research). The survey was web-based and administered nationwide.

Table 2. Descriptive Statistics

Variable	Definition	Obs	Mean	Std. Dev.	Min	Max
Shortfall	Gap between HH EDW and official guideline (*in liter*)	19071	14.12	14.15	-25.5	49.5
Public EDW	Public EDW per person in prefecture (*in liter*)	19071	0.817	5.882	0.011	65.45
Expenditure	Past prefecture government expenditure on disaster recovery (*in k¥/capita*)	19071	0.000	0.002	0	0.130
Professionals	Number of professionals in community-based emergency department service	19071	0.312	0.705	0	14.02
EX-Disaster	Personal experience of disaster, except 2011 Tohoku and 1995 Kobe incidents (*dummy)*	19071	0.167	0.373	0	1
EX-shelter	Personal experience of emergency shelter (*dummy*)	19071	0.102	0.303	0	1
EX-Tohoku	Residence in 2011 located in Tohoku earthquake impact zone (*dummy*)	19071	0.025	0.156	0	1
EX-Kobe	Personal experience of 1995 Kobe earthquake (dummy)	19071	0.052	0.223	0	1
Training	Participation in disaster drill in last five years (*dummy*)	19071	0.167	0.373	0	1
Compliance	Subjective perception of rule compliance	19071	0.328	0.470	0	1
Density	Population density of prefecture (*population/km^2*)	19,071	2,031	2,196	65.42	6,288
Education	Years of secondary education	19071	5.142	2.659	0	10
Income	Monthly HH Income (*in k¥*)	19000	640.81	378.39	200	2000
Children	Number of small children (< 5a)	19071	0.147	0.438	0	4
Elderlies	Number of elderlies (> 64a) requiring care	19071	0.061	0.239	0	1

Table 2 shows the structure of respondents and a number of key descriptive results. A number of features stand out. For example, the average household have a shortfall of about 14 liters below the official EDW storage guidelines. This is in line with previous international findings that most households are insufficiently prepared (compare also DIEM 2010). Categorizing households by preparedness status, we find that 6,691 out of 19,071 households that answered the question stated that they do not store any EDW. This puts the share of unprepared households at 35.1 percent. The share of underprepared households, i.e. those that store some EDW, but have a shortfall relative to the official guidelines, lies at 48.5 percent (9,245 out of 19071). Only 16.4 percent of households (3,135 out of 19,071) have no shortfall and can therefore properly be described as "prepared".

Public supply of EDW per head in Japan in 2012 was around one liter (0.*8l)* on average, but with considerable variation. Some households are located in prefectures in which there is essentially no public EDW stored (0.01*l*) while other household can count on access to more than 65 liters of EDW per head. We exploit this variation in the next section to understand how private households respond to this variation in public EDW storage.

4. Hypotheses and Estimation Method

Theory and previous empirical evidence allow both for the possibility that private households' EDW storage decision is unaffected by public EDW storage levels and for the possibility that it responds negatively to higher levels of public EDW storage. We apply two complementary models to determine which of the two possibilities is supported by our Japanese survey evidence.

Model 1 examines the factors that determine the preparedness *status* of a household, and in particular the role of public EDW storage in determining the status. We distinguish three types of status, i.e. whether the household is unprepared, underprepared, or fully prepared. We adopt, throughout, the null hypothesis that no crowding takes place, placing the burden of proof on crowding.

Hypothesis 1 (order effects): *A higher per capita supply of EDW by government does not affect the likelihood that households are un- and underprepared.*

We test hypothesis 1 using an ordered probit model, with public EDW supply as an explanatory variable. Using an indicator variable that increases with the preparedness status, evidence of crowding out requires a negative sign to be recovered for the coefficient of public EDW supply.

Model 2 considers the possibility that a crowding-out effect could operate either at the extensive and the intensive margin of the households' decision making process, or both. The extensive margin effect of public EDW storage affects a household's choice whether to stay unprepared or to prepare at least to some extent. The intensive margin effect of public EDW storage affects, for the latter households, the their choice of how much EDW to store. The presence and scale of these margins is of obvious interest to policy-makers, particularly in the case of EDWS. Households crowded out at the extensive margin are particularly vulnerable in the case of a disaster, leading to a disproportionate mortality and morbidity impact. The intensive margin mostly affects the time pressure under which government needs to bring disaster relief to the affected population. The empirical validity of these hypotheses is therefore of considerable significance.

For model 2, we therefore test two hypotheses. The first of the two considers the extensive margin.

Hypothesis 2 (extensive margin): *Everything else equal, a household's decision whether to store a positive amount of EDW is unaffected by variations in the locally available public EDW supply.*

The third hypothesis examines the extent to which the level of EDW storage decisions varies with the level of public EDW supplies.

Hypothesis 3 (intensive margin): *Everything else equal, a household's shortfall in EDW storage is unaffected by variations in the locally available public EDW supply.*

We test both hypotheses through a hurdle model. This means that hypothesis 2 is tested by conducting a probit estimation of preparedness for the entire survey population, with public EDW supply as the main explanatory variable. The dependent variable for the probit is the household's preparedness status, which is set to 1 for prepared and underprepared households and to zero for unprepared households. The sign and significance of the coefficient estimate for public EDW storage then forms the basis for a basic rejection test on hypothesis 2 and for statements on the strength of the extensive margin effect.

In a second step, we examine hypothesis 3 by testing how variations in public EDW supply affect the level of preparedness among underprepared and prepared households. The natural object of interest here are underprepared households: Unlike prepared households, underprepared households subject to crowding out have immediate implications for expected mortality and morbidity of catastrophic events. A first test of hypothesis 3 consists of an OLS regression with the level of shortfall in EDW preparedness as the dependent variable and, again, public supply of EDW per head of population as the main explanatory variable.

As controls, we include in the tests for both hypotheses variables that capture, individually and jointly, a household's risk exposure, disaster experience, risk management attitude, and socioeconomic characteristics. For the variables that proxy for risk exposure, disaster experience, and risk management attitude, economic intuition and previous empirical evidence lead to the general prediction that they correlate positively with the propensity to prepare and negatively with the degree of shortfall in preparedness. We also include controls for income, education, and the number of dependent children and elderly people in the household.

5. Estimation Results

5.1. Ordered probit

Table 3 reports the results of the ordered probit estimation, with the three level of preparedness status, ranked from unprepared to underprepared to prepared, as the dependent variable. There are six model specifications. The most basic specification (1) examines the unconditional effect of public EDW storage on preparedness status. Further specifications add risk exposure (2), risk experience (3), risk management attitudes (4), and demographic characteristics as separate covariates. Specification (6) provides a run of the ordered probit model with all covariates included.

Table 3: Effects after ordered probit

	(1)	(2)	(3)	(4)	(5)	(6)
Public EDW	-0.00389***	-0.00371***	-0.00416***	-0.00326**	-0.00114	-0.000448
	(0.00150)	(0.00140)	(0.00160)	(0.00142)	(0.00102)	(0.000991)
EX_Disaster			0.147***			0.135***
			(0.0313)			(0.0256)
EX_Shelter			0.100***			0.0741***
			(0.0272)			(0.0220)
EX_Kobe			-0.0612			0.0455
			(0.0715)			(0.0554)
EX_Tohoku			0.130			0.330***
			(0.104)			(0.0821)

Expenditure		1.871				-10.85
		(14.13)				(9.123)
Professionals		-0.141***				-0.0712***
		(0.0332)				(0.0169)
Training				0.313***		0.304***
				(0.0314)		(0.0323)
Compliance				0.262***		0.241***
				(0.0168)		(0.0186)
Density					6.25e-05***	6.70e-05***
					(1.72e-05)	(1.56e-05)
High school					0.0990***	0.0887***
					(0.0332)	(0.0331)
Tertiary education					0.142***	0.135***
					(0.0355)	(0.0354)
Graduate education					0.105**	0.0917**
					(0.0463)	(0.0462)
Income					0.000252***	0.000209***
					(2.22e-05)	(2.27e-05)
One Child					-0.0317	0.00480
					(0.0259)	(0.0255)
Two Children					-0.146***	-0.0898**
					(0.0448)	(0.0451)
Three Children					-0.436***	-0.421***
					(0.124)	(0.126)
Four Children					-4.788***	-4.662***
					(0.223)	(0.223)
Elderlies					0.000215	-0.0268
					(0.0452)	(0.0465)
Constant cut1	-0.386***	-0.286***	-0.348***	-0.253***	-0.0786	0.127*
	(0.0719)	(0.0626)	(0.0797)	(0.0730)	(0.0660)	(0.0676)
Constant cut2	0.974***	1.092***	1.017***	1.129***	1.293***	1.541***
	(0.0566)	(0.0537)	(0.0663)	(0.0582)	(0.0530)	(0.0625)
Observations	19,071	19,071	19,071	19,071	19,000	19,000

Note: Dependent variable is the preparedness status of the household (unprepared = 1, underprepared = 2, prepared = 3). Standard errors clustered at prefecture level. Significance levels are * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Under hypothesis 1, we expect the coefficient estimate associated with public EDW supply to be statistically indistinguishable from zero. Hypothesis 1 cannot be fully rejected. The coefficient is consistently negative across all six specifications and significantly different from zero and negative in four of the six specifications. This can be interpreted to imply that a higher amount of public EDW storage decreases the likelihood that a household will be found in a higher state of preparedness. The effect is, on the other hand, quantitatively small, even when significant: The marginal effects on the odds ratio never exceeds 0.0002 at the means of each preparedness status. The coefficient also becomes insignificant in specifications (5) and (6), i.e. once demographic controls are included. This leads to result 1.

Result 1 (order effects): *The hypothesis that higher public EDW storage does not impact on the preparedness status of a household cannot be rejected. Even when statistically significant, the effect is of negligible magnitude.*

On the covariates, we find statistically robust evidence for a positive role of disaster experience, education, income, risk management attitudes, and population density on preparedness status, and some evidence for a negative role of dependent children in preparedness. The fit of the ordered probit model is adequate. The deviation between the estimated and observed proportion of unprepared households is less than 0.5 percent (34.67 vs. 35.10), but the proportion of underprepared households is somewhat overestimated (50.0 percent estimated vs. 48.5 percent observed).

5.2. Hurdle model

Tables 4 and 5 report the regression results for the extensive margin (table 4) and intensive margin (table 5) for a number of different specifications. Table 4 shows six columns providing marginal effects at the sample mean based on a probit model, with standard errors clustered at the prefecture level. As in table 1, column (1) reports the results for a univariate specification of crowding without additional controls and columns (2) through (5) specifications with additional covariates for risk exposure (2), risk experience (3), risk management attitudes (4), and sociodemographic characteristics of the household (5). The last column (6) estimates all effects jointly.

The first observation about the table entries for table 4 concerns the degree of robustness of the coefficient estimates and significance levels: Across model specifications, the signs of the sample mean effects remain consistent, except for the coefficient on post-disaster expenditure, and magnitudes are stable for most, but not all variables. The second observation concerns the coefficient associated with the main explanatory variable, namely the amount of public EDW per head of population. As in model 1 reported in table 3, this coefficient is consistently negative for all specifications and remains statistically significant (at around 0.15) for specifications (1) through (4).Once demographic controls are included, however, the effect becomes insignificant. This is summarized in result 2.

Result 2 (extensive margin)*: The hypothesis that higher public EDW storage does not impact on a household's propensity to store a positive amount of EDW cannot be rejected. Even when statistically significant, the effect never exceeds negligible magnitudes: At the sample mean, one additional liter per capita of public EDW supply increases the likelihood that a household will be unprepared by at most 0.17 percent.*

Result 2 summarizes the evidence for a quantitatively small trade-off for the public disaster preparedness: Higher public investments in preparedness increase the likelihood that households do not

Table 4: Marginal effects after probit

	(1)	(2)	(3)	(4)	(5)	(6)
Public EDW	-0.00162***	-0.00156***	-0.00173***	-0.00136**	-0.000437	-0.000179
	(0.000583)	(0.000551)	(0.000613)	(0.000550)	(0.000409)	(0.000389)
EX_Disaster			0.0645***			0.0616***
			(0.0129)			(0.0114)
EX_Shelter			0.0434***			0.0315***
			(0.0126)			(0.0112)
EX_Kobe			-0.0227			0.0112
			(0.0288)			(0.0219)
EX_Tohoku			0.0548			0.122***
			(0.0445)			(0.0336)
Expenditure		0.947				-2.828
		(5.344)				(3.703)
Professionals		-0.0559***				-0.0294***
		(0.0120)				(0.00660)
Training				0.144***		0.138***
				(0.0146)		(0.0127)
Compliance				0.108***		0.0981***
				(0.00764)		(0.00765)
Density					2.61e-05***	2.76e-05***
					(7.48e-06)	(6.74e-06)
High school					0.0510***	0.0473***
					(0.0135)	(0.0136)
Tertiary education					0.0810***	0.0788***
					(0.0149)	(0.0149)
Graduate education					0.0446***	0.0397**
					(0.0172)	(0.0175)
Income					0.000177***	0.000159***
					(1.19e-05)	(1.21e-05)
One Child					0.0302**	0.0464***
					(0.0139)	(0.0137)
Two Children					-0.00541	0.0204
					(0.0182)	(0.0175)
Three Children					-0.0945	-0.0928
					(0.0687)	(0.0685)
Elderlies					0.0528***	0.0437**
					(0.0163)	(0.0170)

Observations	19,071	19,071	19,071	19,071	19,000	19,000

Note: Dependent variable is the decision to store some positive amount of EDW (dummy = 1). Coefficients are marginal effects at sample mean. Standard errors clustered at prefecture level. Significance levels are * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

store any amount of EDW at most by a rate of 0.17 percent per liter per head at the sample mean. To put this finding in perspective, by storing one additional liter per head, the community induces at worst slightly more than 0.17 percent of households to incur an EDW shortfall of 6*lpc* (the recommended amount), implying an additional burden of only 0.01 *lpc* or one percent on public supply.

The estimated effects for the altenative explanatory variables reaffirm the ordered probit results and add to existing evidence on drivers of preparedness: The variables capturing risk exposure are insignificant (for expenditure) or negatively related (emergency staff) to preparedness, thus supporting findings by Koerth et al. (2013) and Asseldonk et al. (2002), respectively. Risk experience relates weakly positively to the decision to prepare, with the exception of experience of the 1995 Kobe disaster, an event more than 20 years in the past.[15] A greater affinity to risk management, expressed through active participation in drills and a general compliance with rules and recommendations, increases the likelihood of EDW storage (Donauhue et al. 2013 and Petrolia et al. 2013), as do income (Osberghaus 2015, Raschky et al. 2013) and education (Botzen et al. 2009; Donahue et al. 2013). The presence of one child and of an elderly care recipient has a positive effect on whether to store some EDW.

Table 5 shows seven columns providing OLS estimates for the crowing effect at the intensive margin, with columns (1) through (6) using the private EDW storage of underprepared households as the

[15] This is in line with previous papers that have noted the relatively rapid decline in the impact of disaster experience on preparedness (Botzen et al. 2009; Kunreuther et al. 1985). Note that we do not control for the age of the head of the household, which could be expected to mitigate the decline in preparedness (Osberghaus 2015).

dependent variable. Standard errors are again clustered at the prefecture level. As above for the extensive margin, column 1 reports the results for a univariate model and columns (2) through (5) report on specifications with alternative explanatory variables. Column (6) estimates all effects jointly. Column (7) differs from the other specifications: Here we report on the results of the multivariate model on the subsample of *prepared* households, i.e. those storing at least the recommend amount of EDW. This allows us to examine crowding effects in this particular subgroup and compare it to underprepared households.

We find robust coefficient estimate signs and, in part, magnitudes, as well as significance levels across model specifications (1) through (6). In contrast to preparedness status and the extensive margin decision whether to store some amount of EDW, the intensive margin decision of *how much* to deviate from recommended EDW storage shows evidence of a positive statistical association with public EDW storage. Higher public EDW is associated with a greater shortfall of EDW stored by the household. Depending on the specificication The magnitude of crowding out lies between 0.018 and 0.027*lpc* for every liter per capita stored by the public. In line with the preparedness status and extensive margin models, the effect is small, here around 2 percent. It is also apparent from column (7) that the subsample of prepared households responds in a fundamentally different way to the same conditions, with some coefficient signs reversed for public EDW, components of risk experience, and risk exposure. We summarize as follows.

Result 3*: We find clear and statistically significant evidence of crowding out of public EDW supply on the level of EDW that underprepared households store. On average, one additional liter per capita of public EDW supply decreases the amount an underprepared household stores by roughly .02 liter per capita.*

Putting result 3 differently, 98 percent of public investment in EDW add to the preparedness of underprepared households in net terms. Column (7) makes clear that prepared households' EDW storage does not vary in a substantive way with public EDW supply. Prepared households' EDW storage shows some evidence consistent with crowding in, but at even lower magnitude than the crowding out for underprepared households (0.6 percent).

An inspection of the covariates reveals both similarities and differences between extensive and intensive margin responses. Risk exposure fully and risk experience mostly play very similar roles at both margins. Likewise, the risk management variable of participating in training increases the *likelihood* of being prepared, but leads to a lower *level* of preparedness, as does income. The most consequential dimension is the presence of dependent household members. While their presence does not affect the *propensity* to prepare in statistically significant way, having children in a household increase the shortfall in EDW storage by between 1.4*lpc* for the first and around 4*lpc* for subsequent children. Every elderly person with care needs is associated with a shortfall of around 5*lpc*. The shortfalls for these groups are at least half of their requirements of 3*lpc* and 6*lpc*, respectively. This means that the private EDW preparedness fails to reflect most of the EDW requirements of these two groups. One explanation for this finding is that such households face higher opportunity costs of EDW preparedness than the average due to less disposable income and less space.

Combining the extensive and the intensive margin effect, we find that increasing public EDW supply affects only the intensive margin in a statistically significant, but quantitatively insubstantial way: It raises the burden on public EDW supply by around 2 percent on account of underprepared households storing less EDW. At worst, the extensive margin effect adds 1 percent. In other words, while present, the crowding out effect is negligible in quantitative terms.

Table 5: OLS estimates for private EDW shortfall

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Public EDW	0.0233***	0.0225***	0.0274***	0.0248***	0.0178***	0.0210***	-0.00666**
	(0.00554)	(0.00515)	(0.00608)	(0.00522)	(0.00434)	(0.00411)	(0.00295)
EX_Disaster			-0.875**			-0.650	-0.439
			(0.404)			(0.425)	(0.532)
EX_Shelter			-0.575			-0.726*	0.422
			(0.372)			(0.393)	(0.425)
EX_Kobe			1.274***			0.715***	0.299
			(0.364)			(0.264)	(0.227)
EX_Tohoku			0.0601			-0.700*	-0.413
			(0.466)			(0.383)	(0.481)
Expenditure		-51.47				32.11	-18.84
		(75.61)				(59.02)	(108.1)
Professionals		0.559***				0.291*	-0.0767
		(0.170)				(0.160)	(0.203)
Training				1.285***		0.949***	-0.0872
				(0.293)		(0.275)	(0.181)
Compliance				-0.752***		-0.905***	-0.566**
				(0.190)		(0.187)	(0.212)
Density					-0.000321***	-0.000323***	-8.70e-05
					(7.12e-05)	(7.44e-05)	(5.53e-05)
High school					0.270	0.262	0.322
					(0.426)	(0.426)	(0.483)
Tertiary Education					-0.440	-0.435	0.584
					(0.391)	(0.390)	(0.392)
Graduate Education					-1.729***	-1.704***	0.304
					(0.411)	(0.408)	(0.454)
Income					0.00462***	0.00463***	0.00117***
					(0.000286)	(0.000283)	(0.000298)

One Child					1.394***	1.314**	0.698*
					(0.512)	(0.513)	(0.400)
Two Children					4.094***	4.088***	3.048***
					(0.513)	(0.515)	(0.527)
Three Children					4.663**	4.309**	
					(2.089)	(2.051)	
Elderlies					5.220***	5.187***	1.302**
					(0.421)	(0.412)	(0.589)
Constant	15.43***	15.93***	15.61***	15.44***	12.18***	12.93***	-8.482***
	(0.272)	(0.258)	(0.298)	(0.265)	(0.415)	(0.470)	(0.419)
Observations	9,245	9,245	9,245	9,245	9,214	9,214	3,115
R-squared	0.000	0.004	0.002	0.004	0.055	0.066	0.015
F	17.62	12.14	.	26.92	77.67	.	.

Note: Dependent variable is the amount of shortfall of a household with positive EDW storage below the recommended amount in liters. Standard errors clustered at prefecture level. Significance levels are * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

In light of the existing evidence on crowding effects and the determinants of HH preparedness, the quantitatively small crowding out effect documented in tables 3 through 5 deserves two comments. One comment is our results raise the possibility that crowding effects may in fact depend on the type of relief government offers. Most papers find evidence of crowding out (see table 1), but that evidence derives from settings in which governments offer cash relief. One explanation for why our findings differ from most the existing literature is that in-kind relief has different effects from cash relief. If so, this would have important ramifications for the design of relief policies. The second comment is that the specific EDW setting makes it plausible that the small crowing effect is a measure of the total, rather than partial, impact of public insurance on self-insurance. This is because either private storage or reliance on public storage effectively exhaust a household's options for managing EDW risks in the event of a catastrophe.[16] The estimated joint crowding effects of 2 percent of public EDW supply therefore provides an unusually close approximation of the total crowding effect of public intervention.

5.2. Robustness checks

Given that insignificant crowding effects of public on private preparedness are the exception rather than the rule in the literature, we conduct a number of robustness checks. One simple check is to aggregate the data up to the prefecture level and rerun the regression exercises at the two margins, one for the share of households that store some amount of EDW and one for the amount of shortfall. In appendix A, we report the results of these two first robustness check, which are consistent with the headline results.

A second check is to see whether the results are sensitive to the specific categorization of households into preparedness status on the basis of the official EDW requirements. This categorization is relevant for distinguishing under-prepared and prepared households. The categorization of unprepared households, on the other hand, hinges on an entirely objective criterion, namely that the household does not to store any EDW. We therefore recode households preparedness status in two ways, once setting a 25 percent higher threshold of EDW storage, once setting a 25 percent lower threshold. We then rerun model 1 on the recoded dataset. The results of this robustness check are presented in appendix B. As is evident, coefficient estimates are very close to those estimated when the official EDW requirements are used for

[16] There may be a small role for insurance through neighbors and other social networks. However, disaster entail highly correlated risk events that render risk sharing ineffective.

determining preparedness status and there are no changes in significance.

6. Conclusion

In light of the recent evidence on how important disaster preparedness is for limiting morbidity and mortality impacts of catastrophes, the relationship between public disaster preparedness and private preparedness intervention has attracted renewed attention. Over the last few years, this has led to a literature that has unearthed important evidence for the presence of a crowding out effect, but also pointed to important subtleties in the presence and scale of the effect. These subtleties in part reflect empirical challenges identified already at the inception of the crowing literature.

The present paper exploited an empirical opportunity created by a unique dataset from a disaster preparedness survey with over 19,000 respondents conducted in Japan in 2012 to address some of these challenges. By focusing on the survey's evidence on emergency drinking water, the paper studies a form of disaster preparedness in which (i) government provides in-kind rather than cash relief, (ii) public and self-insurance are essentially perfect substitutes, and (iii) public and self-insurance exhaust the pool of effective risk management options. Such a setting provides a conducive environment in which to observe possible crowding effects of a popular form of governmental relief and to measure a close approximation to the total impact of a crowding mechanism, if present.

We find little evidence for crowing out at a meaningful scale. Evidence for both the preparedness status and the propensity to store some positive amount of EDW is consistent with the hypothesis that there are no crowding effects and that variations in preparedness status are driven by demographics. At the intensive margin, there is statistically robust evidence among underprepared households that their shortfall of private EDW storage below official guidelines is higher when government stores more EDW, but crowding out is around 2 percent. This negligible impact stands in contrast to evidence the impact of cash relief and could be driven by the in-kind character of public EDW. This is a question that deserves further attention.

Apart from crowding out, our results highlight the particular importance of dependent household member in determining shortfall in preparedness: While households with dependents are marginally more likely to take some preparation, these preparations fall short of the requirements by at least half. This suggests that targeted supply of public EDW to these households is likely to have disproportionate impact. In sum, the present paper adds evidence on how non-hypothetical self-insurance behavior by households responds to in-kind relief by government. This evidence weighs heavily in the direction that in these contexts, crowding out effects, if present at all, are insubstantial.

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Appendix A

Table A.1: Prefecture-level regression for share of households with positive EDW storage

	(1)	(2)	(3)	(4)	(5)	(6)
Public EDW	-0.000242	-0.000649	0.000869	0.00126	0.00120	0.00281*
	(0.00191)	(0.00174)	(0.00227)	(0.00173)	(0.00170)	(0.00139)
EX_Disaster			-0.267			-0.183
			(0.423)			(0.264)
EX_Shelter			0.621			0.545
			(0.558)			(0.351)
EX_Kobe			0.120			-0.0539
			(0.287)			(0.173)
EX_Tohoku			0.152			0.187**
			(0.145)			(0.0863)
Expenditure		1.159				-13.26
		(12.67)				(9.841)
Professionals		-0.140***				-0.0401
		(0.0461)				(0.0341)
Training				0.692***		0.467**
				(0.225)		(0.178)
Compliance				0.598**		0.529**
				(0.293)		(0.195)
Density					0.0191	0.0171
					(0.0156)	(0.0107)
Education					-0.00120	-0.00778
					(0.0537)	(0.0356)
Income					0.000873**	0.000754***
					(0.000343)	(0.000244)
Children					0.430	0.265
					(0.322)	(0.221)
Elderlies					-0.562	-0.785**
					(0.480)	(0.348)
Constant	0.576***	0.653***	0.540***	0.294***	0.0284	-0.0614
	(0.0182)	(0.0282)	(0.0332)	(0.0957)	(0.251)	(0.190)
Observations	47	47	47	47	47	47
R-squared	0.000	0.210	0.155	0.252	0.340	0.784
N	47	47	47	47	47	47

F	0.0162	3.806	1.510	4.842	3.435	8.320

Note: Dependent variable is the share of households in the prefecture that store a positive amount of EDW. Significance levels are * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.2: Prefecture-level regression run for average shortfall in EDW preparedness

	(1)	(2)	(3)	(4)	(5)	(6)
Public EDW	0.00301	0.00170	-0.0130	-0.00126	-0.00708	-0.0149
	(0.0452)	(0.0385)	(0.0567)	(0.0474)	(0.0374)	(0.0376)
EX_Disaster			4.090			2.078
			(10.58)			(7.139)
EX_Shelter			-4.141			-9.649
			(13.94)			(9.513)
EX_Kobe			-4.010			0.216
			(7.170)			(4.692)
EX_Tohoku			-3.620			-4.336*
			(3.619)			(2.338)
Expenditure		183.1				715.5**
		(280.1)				(266.5)
Professionals		1.778				-0.241
		(1.080)				(0.923)
Training		-0.924***				-0.734**
		(0.334)				(0.289)
Compliance				-2.397		-5.614
				(6.158)		(4.834)
Density				-0.972		5.100
				(8.022)		(5.284)
Education					-1.758	-1.045
					(1.161)	(0.965)
Income					-0.00391	0.00387
					(0.00722)	(0.00662)
Children					6.640	8.870
					(7.040)	(5.983)
Elderlies					42.67***	41.26***
					(10.23)	(9.415)
Constant	17.31***	16.77***	17.43***	17.94***	24.09***	15.91***
	(0.433)	(0.771)	(0.831)	(2.621)	(5.192)	(5.154)

Observations	47	47	47	47	47	47
R-squared	0.000	0.336	0.063	0.004	0.420	0.719
N	47	47	47	47	47	47
F	0.00443	5.303	0.555	0.0591	5.943	5.860
r	.	.	.	.	.	.
r2_a	-0.0221	0.272	-0.0509	-0.0654	0.350	0.597
corr	.	.	.	.	.	.
rank	2	5	6	4	6	15

Note: Dependent variable is the average shortfall in EDW by households below official guidelines in the prefecture. Significance levels are * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Appendix B

Table B.1: Effects after ordered probit – Elevated EDW threshold

	(1)	(2)	(3)	(4)	(5)	(6)
Public EDW	-0.00410***	-0.00393***	-0.00438***	-0.00349**	-0.00136	-0.000685
	(0.00153)	(0.00143)	(0.00163)	(0.00146)	(0.00102)	(0.000982)
Density					6.32e-05***	6.85e-05***
					(1.71e-05)	(1.54e-05)
High school					0.110***	0.1000***
					(0.0374)	(0.0375)
Tertiary education					0.156***	0.149***
					(0.0393)	(0.0393)
Graduate education					0.103**	0.0901**
					(0.0449)	(0.0454)
Income					0.000260***	0.000217***
					(2.56e-05)	(2.62e-05)
One Child					0.0247	0.0635**
					(0.0313)	(0.0309)
Two Children					-0.158***	-0.102**
					(0.0424)	(0.0419)
Three Children					-0.363***	-0.348**
					(0.138)	(0.139)
Four Children					-4.797***	-4.599***
					(0.223)	(0.225)
Elderlies					0.00838	-0.0192
					(0.0428)	(0.0436)
EX_Disaster			0.154***			0.141***

	(1)	(2)	(3)	(4)	(5)	(6)
			(0.0295)			(0.0237)
EX_Shelter			0.105***			0.0788***
			(0.0258)			(0.0215)
EX_Kobe			-0.0678			0.0409
			(0.0714)			(0.0501)
EX_Tohoku			0.137			0.340***
			(0.104)			(0.0809)
Expenditure		2.566				-10.34
		(14.20)				(9.384)
Professionals		-0.139***				-0.0682***
		(0.0351)				(0.0180)
Training				0.310***		0.301***
				(0.0323)		(0.0313)
Compliance				0.273***		0.253***
				(0.0175)		(0.0198)
Constant cut1	-0.386***	-0.430***	-0.346***	-0.251***	0.0274	0.156**
	(0.0719)	(0.0745)	(0.0797)	(0.0738)	(0.0633)	(0.0657)
Constant cut2	1.339***	1.302***	1.386***	1.503***	1.783***	1.951***
	(0.0521)	(0.0535)	(0.0622)	(0.0571)	(0.0585)	(0.0573)
Observations	19,071	19,071	19,071	19,071	19,000	19,000

Note: Dependent variable is the preparedness status of the household (unprepared = 1, underprepared = 2, prepared = 3) based on EDW requirements that are 25 percent higher than under official guidelines. Standard errors clustered at prefecture level. Significance levels are * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.2: Effects after ordered probit – Reduced EDW threshold

	(1)	(2)	(3)	(4)	(5)	(6)
Public EDW	-0.00437***	-0.00419***	-0.00469***	-0.00372***	-0.00159	-0.000951
	(0.00150)	(0.00140)	(0.00160)	(0.00143)	(0.00104)	(0.00100)
Density					6.16e-05***	6.60e-05***
					(1.75e-05)	(1.59e-05)
High school					0.0920***	0.0817**
					(0.0321)	(0.0323)
Tertiary education					0.138***	0.131***
					(0.0331)	(0.0331)
Graduate education					0.0964**	0.0831*
					(0.0427)	(0.0428)

Income					0.000289***	0.000244***
					(2.13e-05)	(2.24e-05)
One Child					-0.0512**	-0.0139
					(0.0253)	(0.0248)
Two Children					-0.171***	-0.114**
					(0.0462)	(0.0459)
Three Children					-0.357**	-0.335**
					(0.153)	(0.155)
Four Children					-4.730***	-4.528***
					(0.226)	(0.229)
Elderlies					0.00113	-0.0274
					(0.0432)	(0.0451)
EX_Disaster			0.160***			0.149***
			(0.0334)			(0.0290)
EX_Shelter			0.111***			0.0859***
			(0.0284)			(0.0236)
EX_Kobe			-0.0893			0.0133
			(0.0721)			(0.0565)
EX_Tohoku			0.134			0.337***
			(0.108)			(0.0874)
Expenditure		1.990				-12.26
		(14.65)				(9.510)
Professionals		-0.147***				-0.0758***
		(0.0336)				(0.0171)
Training				0.325***		0.312***
				(0.0360)		(0.0355)
Compliance				0.276***		0.253***
				(0.0161)		(0.0171)
Constant cut1	-0.387***	-0.433***	-0.346***	-0.248***	0.0201	0.145**
	(0.0719)	(0.0742)	(0.0798)	(0.0716)	(0.0618)	(0.0638)
Constant cut2	0.762***	0.722***	0.808***	0.922***	1.192***	1.345***
	(0.0587)	(0.0600)	(0.0681)	(0.0582)	(0.0594)	(0.0596)
Observations	19,071	19,071	19,071	19,071	19,000	19,000

Note: Dependent variable is the preparedness status of the household (unprepared = 1, underprepared = 2, prepared = 3) based on EDW requirements that are 25 percent lower than under official guidelines. Standard errors clustered at prefecture level. Significance levels are * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.